5.16.02 SIEVE ANALYSIS OF AGGREGATES (Kansas Test Method KT-2)

a. SCOPE

This method of test covers procedures for the determination of the particle size distribution of aggregates using standard sieves. KT-2 reflects testing procedures found in AASHTO T 27.

b. REFERENCED DOCUMENTS

b.1. KT-1; Sampling Aggregates

b.2. KT-3; Material Passing No. 200 (75 μm) Sieve by the Wash Method

b.3. AASHTO M 92; Wire-Cloth Sieves for Testing Purposes

b.4. AASHTO M 231; Balances Used in the Testing of Materials

b.5. AASHTO T 27; Sieve Analysis of Fine and Coarse Aggregates

c. APPARATUS

c.1. The balance shall be readable to 0.1% of the sample mass and conform to the requirements of AASHTO M 231 for the class of general purpose balance required for the principal sample mass of the sample being tested.

c.2. Sieves meeting AASHTO M 92. As a minimum, the set of sieves will include the3/8 in (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 μm), No. 50 (300 μm), No. 100 (150 μm) and No. 200 (75 μm) for all aggregates. Gradations with larger sized aggregate will require addition of appropriate larger sieves to the set.

c.3. A mechanical sieve shaker, if used, shall impart a vertical, or lateral and vertical motion to the sieve, causing the particles to bounce and turn so as to present different orientations to the sieving surface. The sieving action shall be such that the criterion for adequacy of sieving is met in a timely manner as described in **f.3.**

c.4. An oven of appropriate size capable of maintaining a uniform temperature of $230 \pm 9^{o}F$ ($110 \pm 5^{o}C$).

c.5. Drying pans.

d. SAMPLES

d.1. Composition: Obtain samples for sieve analysis by the use of a sample splitter or by the method of quartering. Fine aggregate sampled by the quartering method shall be thoroughly mixed and in a moist condition. The sample for test shall be approximately the mass desired and shall be the end result of proper reduction methods. Do not attempt the selection of samples of an exact predetermined mass.

d.2. Fine Aggregates: Samples of fine aggregate for sieve analysis shall have a mass, after drying, no less than 300 g.

d.3. Coarse Aggregate: Samples of coarse aggregate and mixtures of coarse and fine aggregate for sieve analysis shall have a mass, after drying, not less than the amounts indicated in Table 5.16.02-1.

TABLE 5.16.02-1

Sample Size for Determination of
Coarse Aggregate Gradation Tests

Sieve Size[a]	Minimum Mass of Samples (g)[b]
2 1/2 in (63 mm) or more	35,000
2 in (50 mm)	20,000
1 1/2 in (37.5 mm)	15,000
1 in (25.0 mm)	10,000
3/4 in (19.0 mm)	5,000
1/2 in (12.5 mm)	2,000
3/8 in (9.5 mm) or less	1,000

NOTE **a**: To select the sample size, use the largest sieve on which 5 percent or more of the material is specified to be retained.

NOTE **b**: 12.00 in (300 mm) diameter sieves should be used for testing coarse aggregates and in testing samples with a mass of 5,000 g or more. If 12.00 in (300 mm) diameter sieves are not available, the split sample procedure in subsection **g.3.** shall be used.

For convenience, mixtures of coarse and fine aggregates may be separated into two portions by screening the dried sample over a No. 4 (4.75 mm) sieve.

Reduce the material passing the No. 4 (4.75 mm) sieve by means of a sample splitter to a mass of approximately 1,000 g. Wash both portions of the total sample in accordance with KT-3, and conduct a sieve analysis on each portion. Calculate the total combined grading in accordance with subsection **g.3.** of this test method.

e. PREPARATION OF SAMPLES

Dry all samples to a constant mass at a temperature of 230 $\pm$ 9°F (110 $\pm$ 5°C). Determine the mass of the sample to the nearest 0.1 percent. Record this as the original dry mass.

In the case of Cold in Place Recycle, air drying is acceptable.
Samples containing material finer than the No. 200 (75 μm) sieve shall then be washed over the No. 200 (75 μm) sieve as specified in KT-3. Then redry the sample to constant mass.

f. TEST PROCEDURES

f.1. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample, or portion of the sample, if it is to be sieved, in more than one increment, on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in **f.3.**

f.2. Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation. For sieves with openings smaller than No. 4 (4.75 mm), the mass retained on any sieve at the completion of the sieving operation shall not exceed 4 g/in^2 (7 kg/m^2) of sieving surface[c]. For sieves with openings No. 4 (4.75 mm) and larger, the mass in kg/m^2 of sieving surface shall not exceed the product of 2.5 times the sieve opening in mm. In no case shall the mass be so great as to cause permanent deformation of the sieve cloth.

NOTE **c**: The 4 g/in^2 (7 kg/m^2) amounts to 194 g for the usual 8 in (203 mm) diameter sieve. The amount of material retained on a sieve may be regulated by (1) the introduction of a sieve with larger openings immediately above the given sieve or (2) testing the sample in a number of increments.

f.3. Continue sieving for a sufficient period and in such a manner that, after completion, not more than 0.5 percent by mass of the total sample passes any sieve during 1 minute of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one-sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the No. 4 (4.75 mm) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 8 in (203 mm) diameter sieves to verify the sufficiency of sieving.

f.3.a.[1] An alternative to maintaining a snug fitting pan and cover is to sieve the material over an oversized pan. The pan must be large enough to ensure all material is retained during the hand sieving process. Any material leaving the sieve over the top of the rim must be returned to the sieve.

f.4. In the case of coarse and fine aggregate mixtures, the portion of the sample finer than the No. 4 (4.75 mm) sieve may be distributed among two or more sets of sieves to prevent overloading of individual sieves.

f.4.a. Alternatively, the portion finer than the No. 4 (4.75 mm) sieve may be reduced in size using a mechanical splitter according to **KT-1**, **d.2.** If this procedure is followed, compute the mass of each size increment of the original sample as outlined in **g.3.** of this test procedure.

f.5. Determine the mass of each sieve size increment to the nearest 0.1 percent of the total original dry sample mass by weighing on a scale or balance conforming to the requirements specified in **c.1.** of this test method. The total mass of the material after sieving should check closely with original mass of sample placed on the sieves. If the amounts differ by more than 0.3 percent, based on the original dry sample mass, the results should not be used for acceptance purposes.

f.6. If the sample has previously been tested by KT-3, add the mass finer than the No. 200 (75 μm) sieve determined by that method to the mass passing the No. 200 (75 μm) sieve by dry sieving of the same sample in this method.

[1] **f.3.a.** is not found in AASHTO T 27 but provides a realistic approach to monitoring material falling thru the sieve.

g. CALCULATIONS

g.1. This method applies to aggregates for the following uses:
Concrete (except lightweight aggregates which is determined by dry screening).(CA- , MA- ,FA-)

- Bituminous Mixtures. (BM- , SM-)
- Hot Recycle Bituminous Mixtures. (HR-, SR-)
- Maintenance Repair Aggregate (MRA-)
- Aggregate Base Construction. (AB-)
- Portland Cement Treated Base.
- Granular Sub-base.
- Underdrains (wash over No. 100 (150 mm) sieve). (BD-)
- Slurry Seal.
- Shoulder Construction. (AS-)
- Crushed Stone for Backfill.
- Riprap, Wash Checks, etc.
- Cold in Place recycle

Calculate the total percent of material retained on each sieve as follows:

$$\text{Percent Retained} = \frac{100\ (\text{Mass Retained})}{\text{Total Original Dry Mass of Sample}}$$

NOTE: Aggregate for Concrete (except Lightweight), Underdrains, Cover Material, Subgrade Modification, Surfacing or Resurfacing, Surfacing or Subgrade Modification for Secondary Roads, and Crushed Stone for backfill shall have clay lumps retained on the No. 4 (4.75 mm) sieve removed and discarded from the sample before the original mass of the sample is determined.

g.2. This method applies to aggregates for the following uses:

- Cover Material (except lightweight aggregate which is determined by dry screening). (CM-)
- Subgrade Modification. (SR-)
- Surface or Resurfacing. (SA-)
- Surfacing or Subgrade Modification for Secondary Roads. (SS-)
- Aggregates for Ice Control. (AIC-)

Calculate the total percent retained on each sieve as follows:

$$\text{Percent Retained} = \frac{100\ (\text{Mass Retained})}{\text{*Dry Mass of Sample after Washing}}$$

*After removal of all deleterious material.

g.3. Instructions for using split sample procedure (KDOT Form # 645):

g.3.a. Record the total dry mass of sample before separation as A.

g.3.b. Record the total dry mass of material retained on No. 4 (4.75 mm) sieve following separation as B.

g.3.c. Record the total dry mass of material passing the No. 4 (4.75 mm) sieve following separation as C.

$$C = A - B$$

g.3.d. Record reduced mass of material passing the No. 4 (4.75 mm) sieve as D.

g.3.e. Compute percent of material passing the No. 4 (4.75 mm) sieve as follows:

$$E = \frac{100(C)}{A}$$

Where: E = percent of material passing the No. 4 (4.75 mm) sieve in the total sample.

g.3.f. Wash the plus No. 4 (4.75 mm) portion of the sample over the No. 200 (75 μm) sieve, dry and conduct sieve analysis using all regular sieves including the No. 200 (75 μm). Compute the percent of material retained on each sieve as follows:

$$G = \frac{100(F)}{A}$$

Where: G = Total percent of the entire sample that is retained on each sieve.
F = Total mass of the plus No. 4 (4.75 mm) material retained on each sieve size.

g.3.g. Wash the reduced sample of minus No. 4 (4.75 mm) material over a No. 200 (75 μm) sieve, dry and conduct sieve analysis using all regular sieves including the No. 200 (75 μm). Compute the total percent of the reduced minus No. 4 (4.75 mm) sample retained on each sieve as follows:

$$J = \frac{100(H)}{D}$$

Where: J = Total percent of the reduced minus No. 4 (4.75 mm) sample retained on each sieve.
H = Total mass of the reduced minus No. 4 (4.75 mm) material retained on each sieve.
D = Total dry mass of reduced minus No. 4 (4.75 mm)

g.3.h. Calculate the adjusted percent retained on each size sieve for the minus No. 4 (4.75 mm) material as follows:

$$K = \frac{(J)(E)}{100}$$

Where: K = Adjusted percent of minus No. 4 (4.75 mm) material.
J = Total percent of reduced minus No. 4 (4.75 mm) sample retained on each sieve.
E = Percent of minus No. 4 (4.75 mm) material in total sample.

g.3.i. Calculate the combined percentage of material retained on each sieve in the series as follows:

$$R = K + G$$

g.3.j. Record the sieve analysis on the proper KDOT form.

NOTE: The use of the "Work Sheet for Split Sample Gradation and Plastic Index Tests," KDOT Form No. 645, is provided for the above calculations.

h. REPORTING

The results of the sieve analysis and, when required, the percent passing the No. 200 (75 μm) sieve by the Wash Method (KT-3) are reported on appropriate KDOT forms. Report gradation test results to the nearest whole percent, except for the percentage passing the No. 200 (75 μm) sieve is less than 10 percent, it shall be reported to the nearest 0.1 percent, unless otherwise directed (most bituminous mix gradations are rounded to the nearest 0.01 percent). The project number, name of producer, location of deposit, and all other pertinent data are shown on each report.

The first aggregate report issued for each project shall list the Laboratory number under which the latest Official Quality Sample was tested and the results of such tests with the exception that specific gravities will be reported only if required by the specifications. Subsequent reports may list only the laboratory number under which the quality tests were conducted.

i. PRECISION

Precision for sieving aggregates are established in TABLE 5.16.02-2. The estimates for precision are based on results from the AASHTO Materials Reference Laboratory Reference Sample Program.

TABLE 5.16.02-2

	Total Percentage of Material Passing		Standard Deviation (1S), %[a]	Acceptable Range of Two Results (D2S), %[a]
Coarse Aggregates[b]:				
Single-Operator	<100	≥95	0.32	0.9
Precision	<95	≥85	0.81	2.3
	<85	≥80	1.34	3.8
	<80	≥60	2.25	6.4
	<60	≥20	1.32	3.7
	<20	≥15	0.95	2.7
	<15	≥10	1.00	2.8
	<10	≥5	0.75	2.1
	<5	≥2	0.53	1.5
	<2	≥0	0.27	0.8
Multilaboratory	<100	≥95	0.35	1.0
Precision	<95	≥85	1.37	3.9
	<85	≥80	1.92	5.4
	<80	≥60	2.82	8.0
	<60	≥20	1.97	5.6
	<20	≥15	1.60	4.5
	<15	≥10	1.48	4.2
	<10	≥5	1.22	3.4
	<5	≥2	1.04	3.0
	<2	≥0	0.45	1.3
Fine Aggregates:				
Single-Operator	<100	≥95	0.26	0.7
Precision	<95	≥60	0.55	1.6
	<60	≥20	0.83	2.4
	<20	≥15	0.54	1.5
	<15	≥10	0.36	1.0
	<10	≥2	0.37	1.1
	<2	≥0	0.14	0.4
Multilaboratory	<100	≥95	0.23	0.6
Precision	<95	≥60	0.77	2.2
	<60	≥20	1.41	4.0
	<20	≥15	1.10	3.1
	<15	≥10	0.73	2.1
	<10	≥2	0.65	1.8
	<2	≥0	0.31	0.9

NOTE **a**: These numbers represent, respectively, the (1S) and (D2S) as described in ASTM C 670.

NOTE **b**: The precision estimates are based on coarse aggregates with nominal maximum size of 3/4 in (19.0 mm).

WORK SHEET FOR SPLIT SAMPLE GRADATION AND PLASTIC INDEX TEST

Date _____ Inspector _____ Proj. No. _____

Sample No. _____ Material _____ Spec. No. _____

A	Dry Wt. of Total Sample g.		D	Dry Wt. of −4 Reduced g.
B	Dry Wt. of +4 Matl. g.		E	% of −4 in Total Sample
C	Dry Wt. of −4 Matl. g.			

Sieve Size	+4 Material		−4 Material		Combined Gradation			Spec.
	Grams Ret. (F)	$\frac{F}{A} \times 100$ (G)	Grams Ret. (H)	$\frac{H}{D} \times 100$ (J)	$\frac{J \times E}{100}$ (K)	% of +4 (G)	K + G (R)	
1-½"								
1"								
¾"								
½"								
3/8"								
#4								
#8								
#16								
#30								
#40								
#50								
#100								
#200								
#200 Dry								

	Dish No.	Dish + Wet Soil (a)	Dish + Dry Soil (b)	Wt. of Dish (c)	Wt. of Dry Soil (d)	Wt. of Water (e)	% Moist. (f)	P.I. (g)
Liquid Limit								
Plastic Limit								

$d = b - c$ $\quad e = a - b$ $\quad f = \frac{e}{d} \times 100$ $\quad g$ = Liquid Limit − Plastic Limit

Rev. 12-83 D.O.T. Form No. 645